Experiments and Observations on the Vegetation of Plants, which shew that the common Opinion of the Amelioration of the Atmosphere, by Vegetation in Solar Light, is ill founded. By JAMES WOODHOUSE, *M. D. Professor of Chemistry in the University of Pennsylvania, &c.*

To Mr. NICHOLSON.

SIR,

Pater Noster Row, May 27, 1802.

I INCLOSE for the Philosophical Journal, the results of various experiments, made in Philadelphia in the year 1801, upon the seeds, leaves, &c. of a variety of plants, which seem to prove, that growing vegetables, contrary to an opinion almost universally adopted, do not purify atmospherical air; and that whenever Introductory letter.

whenever they appear to afford oxigenous gas, it is by devouring the coal of carbonic acid gas for food, and leaving its oxigen in the form of pure air.

I have the honour to be,
Dear Sir,
With the greateſt reſpect,
Your moſt obedient,
And very humble ſervant,
JAMES WOODHOUSE.

First. *Of the Effects produced by the Germination of Seeds in atmoſpherical Air.*

ermination of eds in atmo- heric air.

On the 3d of June, twelve ſeeds of zea maiz were planted in earth, and confined over water in a glaſs veſſel, in ſeventy ounce meaſures of atmoſpherical air of the purity of 100, and often expoſed to the light of the ſun. On the 12th, the corn had vegetated, and was from two to five inches high. The air being examined at this time, by throwing up one meaſure of it, over lime water, in an eudiometer, gave $\frac{3}{100}$ parts of carbonic acid air. Another meaſure, after being freed from the fixed air, and mixed with an equal meaſure of nitrous air, produced an abſorption of $\frac{30}{100}$. On the 19th, the corn having grown conſiderably, and the air being tried again, no carbonic acid gas appeared, and the purity was the ſame as at firſt. On the 23d, the plants died, and the airs were found to conſiſt of $\frac{5}{100}$ fixed, and $\frac{95}{100}$ azotic gas.

Similar experiments were made with the ſeeds of apium petroſelinum, lactuca ſativa, cucurbita citrullus, phaſeolus ſativus, ſiſymbrium, and raphanus ſativus, and with the ſame reſult.

ıe air loſt oxi- n by uniting carbon; after- rds it became ore pure; and tly its oxigen s totally ab- bed.

The atmoſpherical air, in theſe experiments, appears to be reduced in purity, by its oxigen uniting to the coal of the cotyledons of the ſeed, or to that of ſome animal or vegetable matter contained in the earth in which the ſeeds are planted, or to that of ſome decayed portion of the living leaves.

ıe effect of g. mould on moſt probably m its carbon.

Ingenhouz, Humbold, and Thomſon, have obſerved, that ſoils have the property of abſorbing oxigen; but as it cannot be proved that any pure earth, or mixture of earths, render atmoſpherical air impure, it is certainly more philoſophical to aſcribe the impurity of the air to the formation of the carbonic acid, the baſe of which generally exiſts in all ſoils.

II. *Of*

II. *Of the Effects produced by the Growth of Plants in atmoſpherical Air.*

On the 27th of May, twelve plants of perſicaſia polygonum, two inches high, growing in earth, were confined in a glaſs veſſel in fifty-two ounce meaſures of atmoſpherical air, of the purity of 100, and often expoſed to the influence of ſolar light. On the 4th of June, they had increaſed about two inches in height. The air being examined at this time, was found to contain $\frac{3}{100}$ parts of carbonic acid gas, and to be reduced in purity to 80. Several young plants of rhaphanus ſativus, latura ſtramonium, phytolacca decandra, zea maiz, phaſeolus ſativus, ſidum telephium, amaranthus hyboidus, cucurbita citrullus, ſirymbrium, and lactuca ſativa, were alſo ſeparately confined in from forty to eighty ounce meaſures of atmoſpherical air, which was examined at various times, from one hour to thirty days, after the plants had been placed in it. Carbonic acid gas was generally formed, and whenever this circumſtance happened, the purity of the air was diminiſhed.

Growth of plan in atmoſ. air.

They produce carbonic acid gas, and dimiſhed the pur of the air.

Many of the ſame kind of vegetables were alſo confined in forty ounce meaſures of oxigenous gas, which had been well waſhed in lime water, and the purity of the air was very generally leſſened, fixed air being generated. They turned of a white or yellow colour, and ſoon died, after being placed in atmoſpherical air.

Growth of pla in oxigen dim niſh its purity carbonic acid.

The ſame effects are produced by the growth of plants as by the germination of ſeeds in common air, and by the ſame cauſes. If the leaves are confined a conſiderable time, part of them decay, and the coal of the dead portion, uniting with the oxigen of the atmoſpheric air, generates carbonic acid. This acid is decompoſed by the living leaf. Its coal is abſtracted, while its oxigen is left in the form of pure air.

In confined plants the decaying parts a ford carbon ar form acid, whi the living pla decompoſes.

When the oxigen unites to the coal of the animal or vegetable matter of the ſoil in which the plants vegetate, or to the coal of the decayed parts of the leaves, and makes fixed air quicker than the living parts can decompoſe it, the plants will ſpeedily die.

But when the formation is quicker than decompoſition the plant dies.

When a plant in perfect health, growing in a ſoil which contains little vegetable or animal matter, is confined in atmoſpherical air, it will live a long time, without producing any change in it. Many of the vegetables which were the ſubjects of theſe

When the ſoil contains but little of organized remains, the included plant will live much longer.

experiments, did not affect the air in five days: ome diminiſhed its purity in three hours; and others altered it in a moſt ſlow and gradual manner, cauſing little change in it in twenty days.

Leaves expoſed to ſolar light in a mixture of atmoſpheric and carbonic acid gas.

III. *Of the Effects produced by the Leaves of Plants in atmoſpherical Air impregnated with Carbonic Acid Gas, and expoſed to the Light of the Sun.*

A handfull of the leaves of mimoſa virgata, euphorbia picta, digitalis purpurea, franklinia altamaha, aſparagus officinalis, coryllus avellana, rhus glabrum, ariſtotochia ſiphoe, and periploca græca, were ſeparately expoſed ſeven hours to the light of the ſun, in thirty-ſix ounce meaſures of atmoſpheric air, impregnated with four ounce meaſures of carbonic acid gas, from the carbonate of lime and ſulphuric acid. The fixed air diſappeared, and the atmoſpheric air was ſo much increaſed in purity, as to devour two meaſures of nitrous air.

The carbonic acid diſappeared, and the proportion of oxigen in the mixture was augmented.

The leaves of theſe plants, kept over night in the ſame air, gave carbonic acid gas in the morning; and its purity, in every inſtance, was conſiderably diminiſhed.

In the dark the leaves produced carbonic acid gas.

The leaves of mimoſa virgata and amygdalus perſica, were alſo ſeparately expoſed nine hours to the influence of ſolar light, in forty ounce meaſures of atmoſpherical air, in which fixed air had been formed by leaving a fungus to putrefy it. The carbonic acid gas diſappeared, and the purity of the atmoſpherical air was increaſed from 80 to 80.

Other leaves expoſed to light, with the former reſult.

Table of experiments on leaves expoſed to ſolar light under pump water.

IV. *The following Tables will ſhew the Quantity and Purity of oxigenous Gas, obtained by expoſing a ſmall Handful of the Leaves of Plants to the Light of the Sun, in forty Ounce Meaſures of Pump Water.*

This water was taken from a well ſunk within a few yards of a neceſſary, from which it was impregnated with carbonic acid gas, as appeared from an analyſis. The leaves were ſeparately expoſed in glaſſes arranged near each other, and from eight to thirteen comparative experiments were made at one time.

Leaves

Leaves of	Carbonic Acid Gas, in 100 Parts.	Oxigenous Gas in Drachm Measures.	Purity with one Measure of Nitrous Air.	Do. with two Measures.	Do. with three Measures.	State of the Thermometer.	Time when exposed.
Alcea rosea - - -	From 8 to 9 Parts.	19½	122	146	96	105° to 110° of Fahrenheit.	July 2, 1802.
Zea maiz - - -		16	116	140	54		The day was very clear
Amaranthus spinosa -		15	120	140	68		
Melissa officinalis - -		13	120	130	50		
Hysopus - - -		16	120	138	70		
Convolvulus purpureus -		8	110	110	0		
Malva rotundifolia - -		17	120	140	86		
Lavendula - - -		16	118	130	55		
Rosa centifolia - -		15	112	130	46		
Mirabilis dichtoma - -		16	110	130	40		
Convolvulus purpureis -	From 8 to 10 Parts.	13	110	120	40	100° to 115°.	July 3.
Anthemis nobilis - -		12	114	120	32		Day clear.
Hibiscus Syriacus - -		12	118	130	65		
Polygonum aviculare -		18	114	130	50		
Amygdalus Persica -		10	114	112	12		
Pyrus malus - - -		16	116	120	20		
Platanus occidentalis -		12	120	140	20		
Tilia Americana - -		10	120	138	40		

Leaves of	Carbonic Acid Gas in 100 Parts.	Oxygenous Gas in Drachm Measures.	Purify with one Measure of Nitrous Air.	Do. with two Measures.	Do. with three Measures.	State of the Thermometer.	Time when expoſed.
Siriodendron tulipifia -		14	112	120	25		July 4, 1801.
Populus dilatata - -		14	110	132	60		
Æſculus pavia - -		13	110	130	60		Day generally clear.
Apium petroſelinum -		12	115	132	55		
Convolvulus purpureus -		5	120	120	30		
Helianthus annuus -	8.	13	112	132	62	105° to 110°.	
Ruta graveolens - -		10	120	130	40		
Trifolium paluſtri -		13	120	140	55		
Datura ſtrammonium -		14	112	130	80		
Hyſopus - - -		7	112	132	65		
Blattari verbaſcum - -		12	112	130	45		July 5.
Chelidonium majus - -		18	112	136	80		Day clear and cloudy.
Chryſanthimum Indicum -		14	120	142	63		Twelve ounce mea-
Acer glaucum - -		14	120	139	63		ſures of this oxigenous
Phytolacca decandra -		11	120	140	80		air, after being waſhed
Antirrhinum linaria - -	8 & 9.	18	120	140	65	95°.	in lime water, to free it
Arctum cappa - -		12	120	140	53		from the carbonic acid
Syringa vulgaris - -		8	120	132	40		gas, being expoſed to a
Helianthus altiſſimus -		12	120	140	55		mixture of iron filings and
Polygonum Perſicana -		12	120	140	80		ſulphur, were found to
Cercis Canadenſis - -		12	120	140	60		conſiſt of eight ounce
Sonicera caprifolium -		12	120	140	60		meaſures of oxigenous,
							and four of azotic gas.
Dioſpyros Virginiana -		10	120	120	30		July 6.
Franklinia altamaha -		10	120	102	0		
Chionanthus Virginica -		8	120	100	0		Day clear and cloudy.
Arundo gigantia - -		10	120	130	32		
Aſclepias Syriaca - -		9	120	80	0		Theſe leaves were ga-
Annona triloba - -		10	120	130	40		thered in the evening,
Magnolia glauca - -		10	110	102	0		and kept until morning,
——— tripetala -		16	116	130	40	90° to 110°.	in a cool place.
Xanthoriza tinctoria -	8 to 10.	8	120	130	50		
Conferva civularis - -		10	120	120	30		
Alcea roſea - - -		5	110	70	0		
Sophora indica - -		7	110	80	0		
Laurus ſaſſafras - -		10	120	92	0		

We

We are indebted to Dr. Prieſtley for the diſcovery, that plants expoſed to light yield oxigenous air; and ever ſince it has been made, an opinion has been adopted, that growing vegetables ſupply the oxigenous portion of atmoſpherical air, of which there is a conſtant conſumption, by combuſtion, fermentation, reſpiration, and the calcination of metals.

Opinion that plants ſupply oxigen to the atmoſphere,

If this ſubject is attentively examined, it will be found that plants have no effect in rendering the air of the atmoſphere pure.

ill founded;

Firſt. Whenever oxigenous gas has been obtained from vegetables, carbonic acid gas has been preſent.

becauſe they afford none unleſs carbonic acid be preſent. Experiments of Prieſtley in proof;

Dr. Prieſtley expoſed plants to atmoſpheric air, in which ſpirit of wine and wax and tallow candles had burned out; to air which had been vitiated by the death or putrefaction of mice and fiſhes, and to air which had been frequently taken into his lungs. He alſo obſerved, that there was a flower and leſs production of air from rain and diſtilled, than from pump and ſtagnant water.

The difference between the quantity and quality of the gas, obtained from river water and the ſame water impregnated with carbonic acid, by expoſing plants in it to the influence of ſolar light, will be ſeen by the following table:

and of the author; tabulated

Leaves

Leaves of	Carbonic Acid Gas, in 100 Parts.	Quantity of Gas in Drachm Measures.	Purity with one Measure of Nitrous Air.	Do. with two Measures.	Do. with three Measures.	State of the Thermometer.	Time when expoſed.
Liriodendron tulipifera -	None.	From half a Drachm to one Drachm.	55			110°.	July 7, 1801. Day very clear. The leaves were expoſed in the water of the river Schuyltril.
Cercis Canadenſis -			70				
Tilia Americana -			50				
Salix Babylonica -			32				
Polygonum Perſicaria			30				
Phytolacca decandra			94				
Platanus occidentalis			90				
Alcea roſea - -			84				
Helianthus annuus -			83				
Amygdalus Perſica -			82				
Conferva fontinalis -			80				
Zea maiz - -			75				
Acer glaucum -			90				
Liriodendra tulipifiera -	In ſome of the veſſels none, in others, from 5 to 10 Parts.	6	120	130	40	110°.	July 8, 1801. Day a little hazy, although the ſun ſhone conſtantly. The leaves of the ſame plants, in the ſame river water, impregnated with four quarts of the water, ſaturated with carbonic acid gas, from carbonate of lime and the ſulphuric acid.
Cercis Canadenſis -		6	116	124	30		
Tilia Americana -		5	110	160	0		
Salix Babylonica -		5	120	100	0		
Polygonum Perſicaria		10	120	140	70		
Phytolacca decandra		6	120	140	42		
Platanus occidentalis		3	110	60	0		
Alcea roſea - -		6	120	132	40		
Helianthus annuus -		10	120	110	50		
Amygdalus Perſica -		6	120	138	40		
Conferva fontinalis -		4	120	134	50		
Zea maiz - -		4	115	125	20		
Acer glaucum -		6	120	140	50		

It appears from this table, that the leaves of thirteen differ-t plants, ſeparately expoſed in forty ounce meaſures of the ater of the river Schuyltrill, produced about ten drachm eaſures of air, the principal part of which was azotic gas; hereas the ſame kind of leaves, expoſed in the ſame quan-y of the ſame water, impregnated with carbonic acid, elded ſeventy-ſeven drachm meaſures of oxigenous air, of a ry high degree of purity.

Count

Count Rumford made an attempt, in the year 1787, to overthrow the doctrine of the purification of the air by plants. His arguments were, that leaves confined in water were in unnatural circumſtances, and that pure air could be obtained from other bodies, as fine ſpun glaſs, raw ſilk, common cotton, and that of the poplar tree, expoſed in water to the light of the ſun *.

Count Rumford's experiments to obtain oxigen from water by ſolar light.

The ingenious author of Phytologia alſo ſays, it may be ſuſpected that, in many of the experiments of Prieſtley and Ingenhouz, the production of vital air might be ſimply owing to the action of the ſun's light on the water in which the vegetables were immerſed, like that from the ſilk in the experiments of Count Rumford; and that the fine points or ſharp edges of theſe bodies, contributed only to facilitate the liberation of it when expoſed to the ſun ſhine, which thus diſoxigenated the water by their united effect.

Remarks on Prieſtley's and Count Rumford's experiments.

The experiments of Count Rumford are far from being ſatisfactory. Thirty grains of raw ſilk, at the end of three days, yielded him but $3\frac{3}{4}$ cubic inches of air, and ſometimes four days elapſed before a ſufficient quantity could be collected for an experiment.

Direct experiments with fibrous bodies, which gain leſs in quantity and purity than leaves.

In order to find how much air could be obtained from the "fine points or ſharp edges" of certain bodies acting upon water, the following ſubſtances were expoſed one day to the action of ſolar light, in forty ounce meaſures of pump water.

Filaments of aſbeſtos, baked horſe-hair, common cotton, and that of the aſclepias Syriaca, the flower panicles of rhus cotinus, the fine hairy plumes of clematis criſpa, the ſpikes of panicum glaucum, and charcoal in powder. From each of theſe ſubſtances, from two to four drachm meaſures of pure air were obtained, which devoured nearly two meaſures of nitrous air; conſequently it was leſs pure than that procured from leaves expoſed in the ſame water. There was alſo a much ſmaller quantity of it; for from eight to nineteen drachm meaſures may be obtained in a few hours, by immerſing the leaves of any plant in the ſame water, and expoſing them to ſolar light.

Other ſources air.

Some water, without any mixture, will yield oxigenous gas by the combined action of light and heat; and many ſubſtances placed in water, appear to act merely by raiſing its temperature.

* Tranſactions of the Royal Society for 1787.

The green vegetable matter, which forms on all bodies, immerſed a conſiderable time in water, might alſo have been one of the ſources of pure air, in ſome of the experiments of Count Rumford.

Plants do not decompoſe water; for they do not operate in pure water.

Secondly. Many philoſophers ſuppoſe, that vegetables yield oxigenous gas by the decompoſition of water. Its hidrogen is ſaid to enter into plants, while its oxigen is ſet at liberty in the form of pure air.

If this opinion was true, oxigenous gas ſhould be obtained by expoſing leaves in boiled, rain, diſtilled, river, or lime water, but this cannot be done.

Plants do not (as has been ſuppoſed) emit oxigen and abſorb azote;

Thirdly. Some ſuppoſe that vegetables give oxigenous air to animals, and that the latter yield them azotic gas in return, which they devour for food.

If this hypotheſis were juſt, atmoſpheric air would be increaſed in purity by confining leaves in it when it contained no fixed air; and its purity might alſo be increaſed, after being previouſly diminiſhed, by an additional quantity of azotic air, in the ſame manner.

for freſh leaves do not affect atmoſpheric air,

A handful of the leaves of euphorbia picta, nicotiana tobacco, buxus vulgaris, cinna glauca, mimoſa julibreſcens, jaxus procumbens, coryllus avellana, Herculea fœtida, malva criſpa, pinus ſtrobus, colutea arboreſcens, and epilobium, were ſeparately expoſed four hours to the light of the ſun, in forty ounce meaſures of atmoſpheric air, and its purity was found to be neither increaſed nor diminiſhed. After they had remained ſixteen hours in the air, no effect was produced on it. The leaves were freſh gathered, and no decay could be obſerved upon any part of them.

hough wounded r decaying aves do.

When leaves are plucked promiſcuouſly, and are placed in atmoſpheric air either in the day or night, they diminiſh its purity. Wherever a leaf is perforated, and this is very generally done by inſects, let the perforation be ever ſo ſmall, the part decays, and the coal of this decayed part uniting to the oxigen of the atmoſpheric air, generates carbonic acid, which leſſens its purity.

The

The following table ſhews the effect of the leaves of plants gathered promiſcuouſly, expoſed five hours to the light of the ſun, in forty ounce meaſures of atmoſpherical air, at a temperature of 75° of Fahrenheit. Experiments in ſolar light;

A ſmall handful of the Leaves of	Fixed Air.	Atmoſpheric Air of the St. and Ard. of 100.
Datura ſtrammonium	3	96
Rododendron maximum	5	87
Apium petroſelinum	4	86
Anthemis nobilis	0	100
Sophora auſtralis	2	95
Sedum telephium	0	100
Amaranthus hybridus	10	70

The following table will ſhew the effects produced in one night, on forty ounce meaſures of atmoſpheric air of the purity of 100, by a ſmall handful of leaves gathered promiſcuouſly from a variety of plants. in the dark.

Leaves of	Fixed Air.	Atmoſ. Air.
Ilex aquifolium	5	88
Juniperus officinalis	4	93
Berberis vulgaris	2	86
Franklinia alatamaha	3	85
Rododendron maximum	1	95
Annona triloba	2	88
Buxus vulgaris	2	90
Pinus ſtrobus	2	88
Mitchella repens	0	100
Arclepias Syriaca	5	86
Hamamelis Virginia	0	100
Bignonia radicans	3	77
Xanthoriza tinctoria	1	94
Magnolia tripetala	5	67
Kalmia latifolia	2	85
Pinus picea	3	80
Siriodendron tulipifera	10	65

According to ſome philoſophers, carbonic acid gas is ſecreted by certain vegetables in the night; but as the quantity of this air obtained is always in proportion to the decayed parts of plants,

plants, and to the temperature to which they are ſubjected, it appears more rational to aſcribe the generation of it to the coal of the decayed parts uniting with the oxigen of the air in which they are placed.

eaves expoſed o ſunſhine in a nixture of at- noſpheric air nd azote, pro- uced no effect.

To determine whether plants would abſorb or devour azotic gas, eight ounce meaſures of this air were mixed with thirty-two ounce meaſures of atmoſpheric air, ſo that its purity was reduced from 100 to 91. A handful of the leaves of euphorbia picta and coryllus avellana were ſeparately confined in forty ounce meaſures of this air, and expoſed to the influence of a bright ſolar light five hours. No carbonic acid gas was generated, and the purity of the air was exactly the ſame as when firſt tried. No decayed portion could be obſerved upon theſe leaves.

eaves do not urify the at- oſphere by de- mpoſing its rbonic gas; ecauſe the uantity of this as is very mi- ute,

As it is acknowledged that the leaves, ſtems, and roots of plants, ſeparate the oxigen from carbonic acid, it may be ſaid, that the oxigenous portion of atmoſpheric air is ſupplied by the decompoſition of this gas, as it is always found in the atmoſphere, and often in water in which vegetables grow.

The quantity of carbonic acid gas in atmoſpheric air, is reckoned to be about one part in an hundred. It muſt, however, vary in different places. We would expect to find the moſt of it in cities, where it is formed by combuſtion, reſpiration, fermentation, and putrefaction. If one meaſure of the air of any large city is thrown up over lime-water in an eudiometer, no milky appearance will be produced, ſo that the quantity of carbonic acid in this air muſt be extremely ſmall. As this gas is alſo ſeized upon by alkalis, earths, and metals, and abſorbed by water, the quantity floating in the atmoſphere may be leſs than one part in ten thouſand.

ld plants dete- orate the air uch more.

When we conſider likewiſe, that the oxigen is never ſeparated from the carbonic acid by leaves, but when they are expoſed, in contact with it, to the light of the ſun; and that every perforation made in the living leaf, however minute, by an inſect, cauſes the part to decay, and abſorb oxigen by day and by night; and that, in the autumn in ſome countries, all leaves fall on the ground, ferment or putrify, and thus diminiſh the purity of common air; and that the petals and fruit of vegetables have the ſame effect, we muſt pronounce, that the oxigenous portion of atmoſpheric air cannot be ſupplied by vegetation.

Dr.

THE air of the atmosphere, according to the most celebrated chemists, is composed of twenty-two parts of oxigenous gas or air, and seventy-eight parts of azotic gas. There is a constant consumption of the oxigenous portion of this air, by the burning of combustible bodies; by the respiration of animals; by the fermentation and putrefaction of vegetable and animal substances; and by the calcination of metals. The oxigenous gas, decomposed by respiration and combustion only, in the city of London, is supposed to amount to the enormous quantity, of five millions cubic feet an hour. (NICHOLSON'S *Philosophical Journal.*)

The atmospheric air of Great Britain, France, of parts of Africa, and of America, has been examined by philosophers, and has been found to be exactly of the same degree of purity.

The oxigenous gas contained in it, is in the same proportion, at all times and in all places, in rainy or in dry weather, in the depth of winter, and in the middle of summer, on the land and on the ocean, in the crowded city and remote village.

In consequence of a most valuable discovery, made by the illustrious Dr. PRIESTLEY, that growing vegetables under certain circumstances, exposed to the light of the sun, yield oxigenous gas; an opinion has been adopted, that they are the sources of the oxigenous part of common air.

This sentiment has been adopted by the chemists of all nations, but has lately been controverted by Dr. JAMES WOODHOUSE, professor of chemistry in the University of Pennsylvania. (NICHOLSON'S *Philosophical Journal.*)

The Doctor reasons in the following manner:

1st. He says, whenever oxigenous gas has been obtained from vegetables, carbonic acid, or fixed air, has been present. Upon reviewing the experiments of Dr. PRIESTLEY, he finds that this circumstance has actually taken place. The Dr. exposed plants to the influence of light, in atmospheric air, in which spirit of wine, and wax, and tallow candles, had burned out; to air which had been vitiated by the death or putrefaction of mice and fishes; and to air which had been frequently taken into his lungs, and found that the purity of the air, was in every instance restored. (PRIESTLEY on air. Vol. iii. p. 247 to 349.)

In all these cases, carbonic acid, (which is composed of carbon and oxigen) was formed ; the vegetable devoured its coal for food, by which means its oxigen escaped, in the form of pure air.

2dly. The seeds of Zea mayz or Indian corn, of *apium petroselinum* or parsley, of *lactuca sativa* or lettuce, of *cucurbita citrullus* or the water melon, of *phaseolus sativus* or beans, and of *raphanus sativus* or radishes, were planted in earth, and made to vegetate in atmospheric air, confined over water in vessels of white glass, and exposed to the action of solar light. This air, when examined at various times, was found to be reduced in purity, and when its oxigenous portion was completely absorbed, the plants died. Its oxigen united to the coal of the cotyledons of the seeds, or to that of some animal or vegetable matter contained in the earth, in which they were planted, or to that of some decayed portion of the leaves, and formed carbonic acid, quicker than the living plant could decompose it. To these experiments, we may add, that the celebrated and accurate SCHEELE observed, that beans growing in atmospheric air, always rendered it impure.

3dly. Young plants of *datura stramonium* or Jameston weed, of *phytolacca decandra* or the poke, of Zea mayz or Indian corn, &c. growing in earth, were exposed to solar light in from forty to eighty ounce measures of atmospheric air, which was examined at various times, from one hour to thirty days after the plants had been placed in it. Carbonic acid gas was generally formed, and whenever this circumstance happened, the purity of the air was diminished.

When a plant in perfect health, growing in a soil, which contains little vegetable or animal matter, is confined in atmospheric air, it will live a long time without producing any change in it. Many of the vegetables, which were the subjects of these experiments, did not affect the air in five days; some diminished its purity in three hours, and others altered it in a most slow and gradual manner, causing little change in it in 20 days.

4thly. Many of the same kind of vegetables were also confined in forty ounce measures of oxigenous gas, which had been well washed in lime water, and the purity of this air was very generally lessened, carbonic acid being formed.

5thly. A small handful of the healthy leaves of a variety of plants,

containing no decayed parts, were exposed during four, six, and eight hours to the influence of the light of the sun, in atmospheric air confined by water, and its purity was found to be neither increased nor diminished.

6thly. The leaves of various vegetables gathered promiscuously, exposed in the same manner, generally diminished the purity of atmospheric air, several degrees.

7thly. A handful of the leaves of several hundred different plants, among which may be mentioned, those of the apple, pear, peach, poplar, fringe, and persimmon trees, were separately exposed during several hours in glass vessels to solar light, in forty ounce measures of pump water, and from five to nineteen drachm measures of oxigen air, were produced in each vessel. Upon analysing the water, it was found to contain carbonic acid, with which it had been impregnated from a necessary, which stood within a yard of the pump.

8thly. The leaves of thirteen different plants, were separately exposed in the usual manner, in forty ounce measures of the water of the river Schuylkill, and about ten dram measures of air were procured, the principal part of which was azotic gas, which was disengaged from the water. No carbonic acid could be detected in the water of this river.

There are three wooden bridges erected over the Schuylkill, which rest upon large wooden logs, upon which great quantities of a species of conferva grow, and which is covered by the water. Upon viewing this vegetable when the sun shone upon it, for several hours, at different times, for several years, no air could be seen to form upon it, or to rise through the water.

9thly. The leaves of the same vegetables were exposed to light, in the same manner, in the same river water, impregnated with four quarts of the water, saturated with carbonic acid, from the carbonate of lime and the sulphuric acid; and seventy-seven drachm measures of oxigenous air of a very high degree of purity, were obtained.

10thly. No oxigenous air could be procured by exposing vegetable leaves in boiled, distilled, rain, or lime water; a proof that they do not decompose water.

11thly. Atmospheric air was impregnated with carbonic acid gas,

and an handful of the leaves of nine different vegetables, were separately exposed in it, to light, seven hours. The fixed air disappeared, and the atmospheric air was greatly increased in purity.

12thly. The limbs of trees covered with healthy leaves, and some vigorous evergreens growing in their natural soil, were confined from one day to a month, in atmospheric air over water, and exposed to light, and its purity was never found to be increased, but was generally considerably diminished.

These experiments incontestibly prove, that whenever oxigen gas has been obtained from vegetables, by exposing them to the influence of solar light, carbonic acid has been present, and that it is from the decomposition of this gas, that the pure air is obtained.

As it is acknowledged that the leaves of plants separate the oxigen from carbonic acid, it may be said, that the oxigenous portion of atmospheric air is supplied by the decomposition of this gas, as it is always found in the atmosphere. The quantity of carbonic acid, accidentally diffused, in atmospheric air, (for it is not one of its component parts) is reckoned to be about one part in an hundred. It must however vary in different places. We would expect to find the most of it in cities, where it is formed by combustion, respiration, fermentation, and putrefaction. If one measure of the air of any great city, be passed up over lime water, in an eudiometer, no carbonate of lime will be formed, so that the quantity of carbonic acid in this air, must be extremely small. As this gas is also seized upon by alkalies, earths and metals, and absorbed by water, the proportion of it in the atmosphere may be less than one part in ten thousand.

When we consider likewise, that the oxigen is never separated from the carbonic acid by leaves, but when they are exposed in contact with it to the light of the sun, and that every perforation made in a living leaf, however minute by an insect, causes the part to decay, and absorb oxigen by day and by night; and that in the autumn, in some countries, all leaves fall on the ground, ferment and putrify, and thus diminish the purity of common air, and that the petals and fruit of vegetables, have the same effect, we must pronounce, that the oxigenous portion of atmospheric air cannot be supplied by vegetation.

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Dr. Darwin ſuppoſes, that the air in the air bladders of vegetables ſerve to oxigenate the ſeed. The air of the air bladders of cardioſpermum halicacabum, ſtaphylia trifoliata, colutea arboreſcens, and ſophora auſtralis being examined, was found to be a little worſe than the air of the atmoſphere.

Air bladders of various plants contain air worse than that of the atmoſphere.

NLM copy: bound between p. 12 and p. 13 is a bifolum taken from a contemporary publication; the bifolium is paginated 264-267 and has a running title ("VEG"); printed on the bottom of p. 267: "Domestic Encyclopedia, American Edition"; includes passage citing this Woodhouse publication.